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Errors and misconceptions in solving linear inequalities in one variable

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Abstract

Linear inequalities are mathematical expressions that compare two expressions using the inequality symbol, in either be algebraic or numerical or both. However, in solving either of these types some student-teachers commit errors that have been backed by associated misconceptions. This research examined these errors and the associated misconceptions thereafter. Guided by two research questions, the researchers adopted the qualitative narrative inquiry design. The purposive sampling was employed to select 15 student-teachers who met the best requirement that fits the purpose, problem, and objective of a qualitative narrative inquiry. The main instruments were interview guides, where the participants and researchers collaborated with each other to ensure that the story was properly told and aligned with linear inequalities through field notes, observations, photos and artefacts. The narrative analysis started with verbatim transcription of the narratives and ended with deductive coding. The results were scanned copies of participants' sample narratives that were pasted at appropriate places and discussed. Consequently, it was concluded that student-teachers lacked the basic rules, procedural fluency and skills, and formulation of linear inequalities. These errors emanated from misconceived methods and rote memorization. It was therefore recommended that educators imbibe practical and everyday methodologies into the teaching and learning of linear inequalities.

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INTRODUCTION

Mathematical inequality embodies a statement, contrived from expressions comprising one or more symbols (<, >, ≤, ≥), serving to compare two numerical values. In tackling linear inequalities, students are tasked with deciphering unknown variables, their interrelations, and symbolically representing these relationships to problem-solve (Gravemeijer et al., 2017; Msomi & Bansilal, 2022). Consequently, inequality is a central pivot in basic arithmetic concepts, establishing an essential gateway to a multitude of mathematical topics, inclusive of equations and various functional types (Karthik, 2023).

In the realm of applied mathematics, an error signifies the discrepancy between a true value and its estimated or approximated counterpart. A quintessential example in statistics is the difference between an entire population's mean and a sample drawn from said population's mean. Numerical analysis exhibits round-off error, illustrated by the variance between the true value of an irrational number like π and rational expressions' values (Britannica, 2020). Error origins were attributed to a combination of carelessness, inadequate foundational knowledge like struggling with multiplication and division of whole numbers, difficulties in grasping integer concepts due to familiarity with whole numbers, and confusion over rules, which is a manifestation of superficial understanding. An investigation into common student errors and their potential causes was conducted among teachers. The primary source of errors and misconceptions was identified as shallow understanding, possibly stemming from educators rushing through the extensive syllabus, leading students to resort to rote learning due to their shallow grasp of the material (Khalid & Embong, 2020).

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Conversely, a misconception represents an erroneous belief or view arising from a misunderstanding. Misconceptions tend to emerge due to inadequate prior instruction, unstructured thinking, or poor recollection (Allen, 2007). In mathematics education, the concepts of errors and misconceptions are distinct yet interconnected. Errors signify inaccuracies, whereas misconceptions stem from misunderstanding. Misconceptions arise when students mistake a false concept for a true one, and errors can be the consequence of such misconceptions (Arnawa et al., 2019).

Jupri et al. (2022) posit that pre-service teachers encounter misconceptions when working with linear and quadratic inequalities. These individuals commit errors in resolving linear inequalities, particularly in representing the solution as an interval and in operations involving multiplication or division by negative numbers. Many students view linear inequalities as a mathematical hurdle due to their misconceptions and learning difficulties (Zulhendri et al., 2022). Fumador & Agyei (2018) implemented a quasi-experimental model featuring a non-equivalent (pre-test, post-test) control group. The study's outcomes indicate that the Diagnostic Conflict Teaching approach was more adept at addressing students' algebraic errors and misconceptions compared to conventional methods. A qualitative narrative inquiry was employed in this study to decode the observed phenomena.

Statement of the Problem

Scholarly works (Msomi & Bansilal, 2022; Karthik, 2023) have continually emphasized the struggle of students in comprehending and employing the three primary inequality symbols ($<$, $>$, $\leq$, $\geq$). Some learners fail to distinguish between $<$ and $\geq$ or $>$ and $\leq$ when represented in textual sentences. This introduces heightened challenges in tackling real-world problems that incorporate inequalities in day-to-day circumstances.

As per the report from the West African Examinations Council (WAEC, 2020), the primary examiner's documentation reveals that students struggle to respond effectively to questions related to linear inequalities (BECE, 2017-2020). The reports chronicle numerous errors and misconceptions surrounding inequalities. The most salient errors captured in these reports include confusing equations with inequalities, incorrect multiplication with negative coefficients, and erroneous representation of the number line as solutions. In all these instances, students have consistently received lower marks, resulting in an overall mediocre performance in the subject.

The educational system at the College of Education strives to mold student-teachers into future educators for various pre-tertiary educational levels. Linear and quadratic inequalities play a significant role in the mathematics curriculum, but the performance of these student-teachers leaves much to be desired (Ali & Wilmot, 2016). If such deficiencies afflict student-teachers at the university level, those who are tasked with delivering the mathematics curriculum, it indeed provides a justifiable cause for concern. Consequently, this research aims to answer the following research questions:

1. What are the common errors and misconceptions that student-teachers commit in linear inequalities?
2. Why do student-teachers make these errors and misconceptions in linear inequalities?

Theoretical framework

The genesis of errors and misconceptions in mathematical understanding can be traced back to Richard Skemp's delineation of relational and instrumental understanding. Relational understanding refers to the inductive grasp of a mathematical formula, its derivation, and its application in different scenarios. Conversely, instrumental understanding involves the deductive recollection of a formula and its application in solving mathematical problems, without much focus on the derivation process (Makonye & Fakude, 2016). Makonye and Fakude (2016) posit that the inability to derive the formula forms the crucial gap in deep understanding of the concept, thereby leading students to commit errors and misconceptions in mathematics.

In line with constructivist theory, Von Glaserfeld's theory proposes that a child's learning emerges from the interactions between pre-existing ideas and newly introduced concepts. This theory suggests that a child's inability to create and recreate ideas could result in the mindless memorization and recollection of mathematical formulas. Consequently, instrumental learning may emerge as the primary culprit behind errors and misconceptions. For instance, a student-teacher

who consistently asserts that the inequality sign changes direction when a linear inequality is divided by a negative number fails to understand that the same applies in multiplication scenarios (Makonye & Fakude, 2016).

Ali (2019) reported instances where teachers were taken aback and disheartened upon realizing their students' inability to comprehend basic conceptual structures in school mathematics. Numerous errors and misconceptions emerge due to deficits in conceptual understanding, inappropriate reasoning processes, and flawed conceptual generalizations. Students tend to focus on memorizing theorems, formulas, and algorithms, ultimately leading to errors and misconceptions. However, Ernest (2018) proposes that the occurrence of errors and misconceptions is a natural part of mathematical learning.

Ernest (2018) attributes the sources of errors and misconceptions to the disparities between students' pre-existing knowledge structures (schemas) and new ideas arising from assimilation and accommodation processes. Ernest suggests that these sources of errors spawn ignorance, uncertainty, chance, and reliance on past knowledge. To comprehensively and systematically address errors and misconceptions, Ali (2019) highlights three critical factors: ontogenic obstacles (developmental challenges related to cognitive stages), didactic obstacles (instructional challenges linked to the choice of alternate teaching methods), and epistemological obstacles (instructional challenges related to concept construction).

METHOD

Methodology

In the current study, the investigators utilized a narrative inquiry approach to decode the phenomenon of errors and misconceptions in mathematics. Typically, narrative inquiry chronicles the experiences of an individual or a small group, shedding light on the unique perspective or lived experience of that individual, primarily through interviews. These interviews are then transcribed and arranged into a sequential narrative. This design has bestowed a greater voice upon student-teachers, who are often overlooked in the classroom and whose comprehension of linear inequalities is regrettably superficial and severely insufficient (Librarians, 2022).

As posited by DeMarco (2020), a qualitative narrative inquiry design is underpinned by three elements: temporality (which reflects the timing of the experiences and their potential influence on the future), sociality (which takes into account the cultural and personal impacts of the experiences), and spatiality (which considers the environmental context during the experiences and its influence on these experiences). These three components provided the student-teachers with an opportunity to recount their personal experiences regarding linear inequalities using sample scripts and to recall specific instances that triggered the emergence of errors and misconceptions (De Marco, 2020).

Sample and Sampling Method

The study implemented a purposive sampling strategy, a widely employed technique in narrative inquiry research. The participants were chosen because they were deemed to satisfy the study's requirements optimally, aligned with the purpose, problem, and objectives of the research. While narrative inquiry studies do not mandate a specific sample size, the researchers engaged 15 participants in this study. The selection process was concluded when no further unique information was anticipated, averting the potential for redundancy in the sampling (DeMarco, 2020).

Instruments

The primary research instruments consisted of interview guides. During the interviews, the participants and researchers worked collaboratively through the research process to ensure the narratives were effectively conveyed and directly related to linear inequalities. There was considerable interaction with the participants to amass comprehensive narratives via a variety of information types, including field notes, observations, photos, and artefacts. Field tests involving a panel of mathematics experts were conducted to review the research protocol and interview questions for alignment with the research queries (DeMarco, 2020).

Data Analysis

The narrative analysis commenced with the verbatim transcription of the narrative interviews, taking care to include pauses, filler words, and any unique expressions or personal idiosyncrasies. The subsequent stage involved coding the responses. Deductive coding was utilized, in which predetermined codes were established based on the research questions, and excerpts that best fit these codes were identified (Nasheeda et al., 2019; Delve Tool, 2020). Digitized copies of participants' narratives were incorporated at relevant junctures, facilitating interpretation and discussion and aiding the application of any classroom-oriented methodology (Lapum et al., 2015).

Ethical Considerations

Four central ethical considerations were identified and addressed in this study: anonymity, confidentiality, informed consent, and trustworthiness. Anonymity was maintained by either not collecting personal identifying information (like name, address, email address), or ensuring the responses could not be linked to individuals' identities. Identifying information was collected only when indispensable to the study protocol (Endicott, 2023).

Confidentiality was upheld such that only the researchers could link the responses to individual participants, with efforts taken to prevent external parties from making this link (Endicott, 2023). Informed consent emphasized the researchers' responsibility to thoroughly apprise participants of the research aspects in understandable language, covering the study's nature, participants' potential role, researcher's identity, funding source, research objectives, publication and utilization of results, and potential risks and benefits (Ali, 2019).

Trustworthiness was ensured through prolonged engagement and persistent observation to enrich the narrative quality, triangulation via multiple data sources, thick description to provide a comprehensive contextual understanding, and member checking to confirm the accuracy of interpretations (Ali, 2019). Concurrently, the researchers conducted member checking, which is vital for validating the credibility of results and is foundational to high-quality qualitative research. The results were returned to participants to validate their accuracy and resonance with the participants' personal experiences (DeMarco, 2020).

RESULTS AND DISCUSSION

The objective of this study was to delve into the errors and misconceptions that occur when solving problems related to linear inequalities in mathematics. Two research questions were addressed in this segment. The first research question aimed to identify the specific errors and related misconceptions committed by student-teachers. The second research question aspired to elicit detailed narratives explaining why these errors and misconceptions occur.

Research Question 1: *What are the prevalent errors and misconceptions student-teachers make in linear inequalities?*

The primary aim of this research question was to investigate the common errors and corresponding misconceptions student-teachers commit when resolving problems related to linear inequalities. To facilitate this, Table 1 details the different types of errors and their associated misconceptions when dealing with linear inequalities. Subsequently, nine cases representing these errors were transcribed, scanned, and inserted into Figures 1 through 9.

Table 1. Common Errors and misconceptions

Students' errors	Percentages (%)	Students' misconception	Percentages (%)
Rules mixed up	79.0	Expressing linear inequalities as equations	72.3
Surface understanding	73.5	Representing inequalities on a number line	75.7
Inability to assimilate concepts	73.5	Incorrect common denominator	64.4
Carelessness	70.6	Oversimplification	45.7
Poor knowledge	58.2	Only one value makes an inequality true	51.9
Expressing inequalities as equations	52	Inequalities and equations are the same	49
Representing inequalities on a number	47	Limited geometrical understanding	43
Incorrect common denominator	43	Inequalities are not fractions	39

The feedback presented in Table 1 indicates that the most significant error, accounting for 79.0% of responses, was 'confusion of rules' when solving problems related to linear inequalities. The linked misconception was that student-teachers regularly treated linear inequalities as equations. It was observed that the majority of participants struggled with the correct application of rules for linear inequalities, often misapplying these rules when performing addition or subtraction operations within an inequality. The least frequent error stemmed from inadequate knowledge, leading to the misconception that a linear inequality is satisfied by a single value only. Figures 1 through 9 present transcribed narratives that were subsequently coded into predetermined thematic categories.

Case 1: Confusion of Rules Error

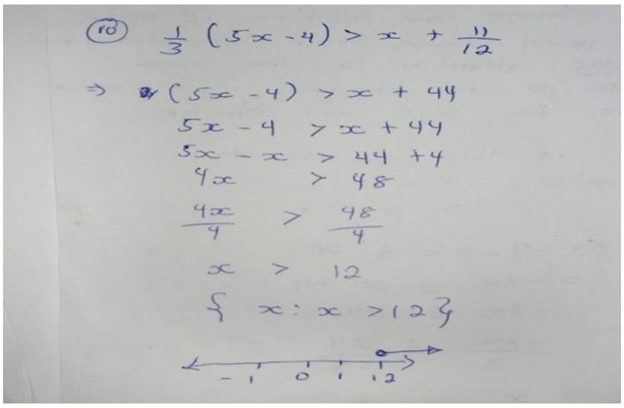

Figure 1. Confusion of rules error

The narrative in Figure 1 offers a sample of the confusion of rules error committed by the participants. From the transcript, it is evident that a majority of the student-teachers made this error, mainly because they did not understand the correct application and context of the rules. While some student-teachers managed to group like terms and simplify them, they were unable to correctly apply the subsequent rules to validate the inequality. This might be a result of teaching rules before students have adequately grasped the concept. Upon closer inspection of the error, it becomes apparent that student-teachers erroneously believed that negative signs simply represent subtraction and do not affect the structure of equations.

Case 2: Superficial Understanding Error

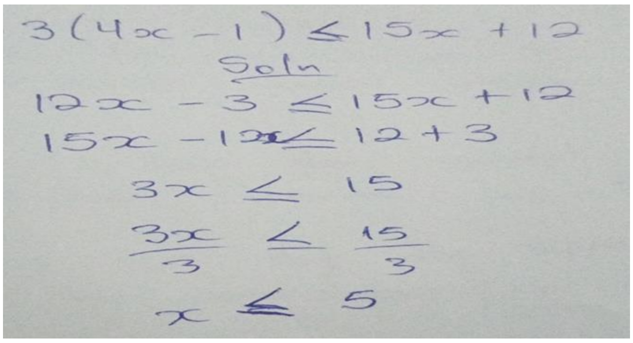

Figure 2. Superficial understanding error

The narrative depicted in Figure 2 demonstrates that the student-teachers knew how to apply the rules of linear inequalities, as evidenced by their multiplication of the expression in the parentheses by 3 to get 12x -3, their simplification of the equation to obtain 12x - 3 ≤ 15x + 12, and the application of the operational rule by grouping like terms to yield 15x − 12x ≤ 12 + 3. Despite correctly applying the basic arithmetic rules of linear inequalities, they made an error in the final solution due to their inappropriate use of addition and subtraction operations. The error mainly occurred when they attempted to change the positions of the inequality signs and symbols in the linear inequalities. This is a common issue when students do not fully understand the impact of multiplication or division of the linear inequality by a negative coefficient.

Upon a more detailed examination of the transcript, it was revealed that some student-teachers were unable to explain the process they used to solve certain inequality problems. This type of error was committed by roughly three-quarters (73.5%) of the student-teachers, an unfortunate circumstance that cannot be overlooked! This exemplifies a case of superficial understanding where students merely remember rules, such as a negative multiplied by a negative equals a positive, and apply them indiscriminately. Some student-teachers applied these rules inappropriately when performing addition or subtraction operations on linear inequalities. Although some of them provided correct answers, they were unable to explain their process when asked.

Case 3: Difficulty in Concept Integration

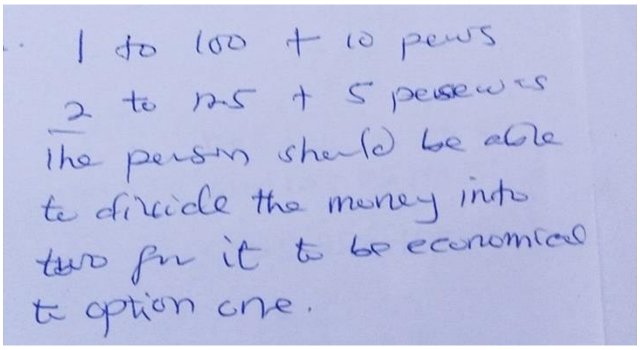

Figure 3. Concept Integration Error

The outcomes presented in Figure 3 illustrate that the respondents were capable of identifying variables. However, their interpretation and comprehension of the question led them to devise a solution that was congruent with their understanding, without formulating an inequality from the provided word problem. This suggests that respondents had difficulty translating words or phrases into mathematical notation, which is a crucial step in solving word problems. The error appears to stem from the challenge of converting verbal relational statements into symbolic expressions, or translating from natural language to mathematical language. The researchers associate this error with misconceptions arising from the literal translation of English statements. After posing the same question to all participants, it was observed that 73.5% encountered challenges in converting word problems into linear inequalities. It was discerned that many struggled to derive linear inequalities from the given word problem, as illustrated by the question, "A rental car company offers two options..." The participants displayed an array of procedural errors which were deemed inexcusable.

Case 4: Oversight Error

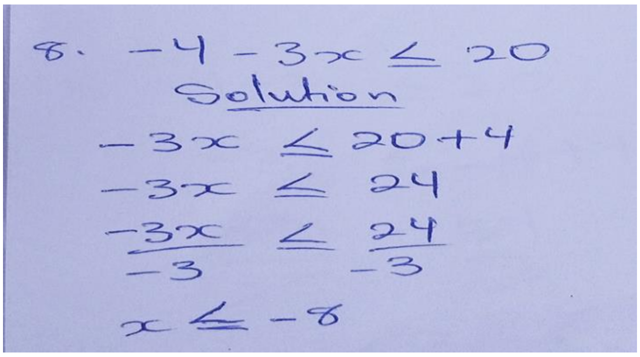

Figure 4. Erroneous Placement of the Inequality Sign

The account depicted in Figure 4 represents the respondents' typical approach to solving the linear inequality $-4 - 3x \leq 20$. Here, the respondents aptly employed the substitution method in the initial step. They multiplied both sides of the equation by -3 and simplified it to yield $-3x \leq 20$. Subsequently, they subtracted -3 from both sides and simplified further. However, when expressing the final result in inequality form, they overlooked the fact that the coefficient was negative, which should have reversed the direction of the inequality sign. Instead, the sign remained unchanged as ≥.

The final answer, therefore, was incorrect. Astonishingly, this error was made by 70.6% of the participants!

Case 5: Deficient Understanding Error

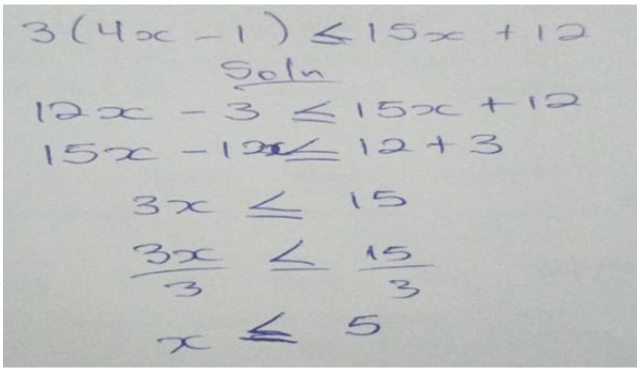

Figure 5. Deficient Understanding Error

The narrative captured in Figure 5 indicates that respondents applied the rules of linear inequalities and multiplied the expression in parentheses by 3 to obtain 12x - 3, subsequently simplifying the equation to 12x - 3 ≤ 15x + 12. They also implemented the operational rule by grouping like terms, resulting in 15x – 12x ≤ 12 + 3. Although they engaged the basic arithmetic rules of linear inequalities, the inappropriate application of addition and subtraction operations during the simplification phase led to an error rooted in deficient understanding. This term encompasses errors resulting from ignorance, conceptual gaps, or insufficient information. There was evident confusion in dealing with parentheses, indicating a lack of clarity on how to eliminate them. This error was evident among approximately 58.2% of the participants, revealing a weakness in basic knowledge regarding the manipulation of parentheses and simplification of linear inequalities. Some participants even struggled to confidently engage in multiplication and addition of integers.

Case 6: Misrepresentation of Inequalities as Equations

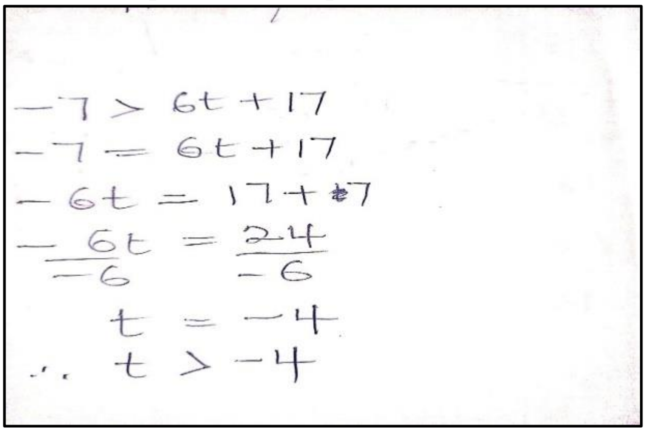

Figure 6. Misrepresentation of Inequalities as Equations

Figure 6 showcases a common misstep where numerous student-teachers mistakenly equated the process of solving inequalities and equations, treating them as identical. Consequently, they approached a linear inequality problem as if it were an equation. For example, in attempting to solve the inequality -7 > 6t + 17, they followed the same procedure as if solving the equation -7 = 6t + 17. This led them to conclude that t=-4. Subsequently, when reintroducing the inequality sign, they simply obtained x>-4 as the solution. However, they neglected the crucial rule that states multiplying or dividing by a negative coefficient reverses the direction of the inequality sign. Therefore, the correct solution should have been t<-4. It was discovered that this error was made by 52.0% of the student-teachers.

Case 7: Representation of Inequalities on the Number Line

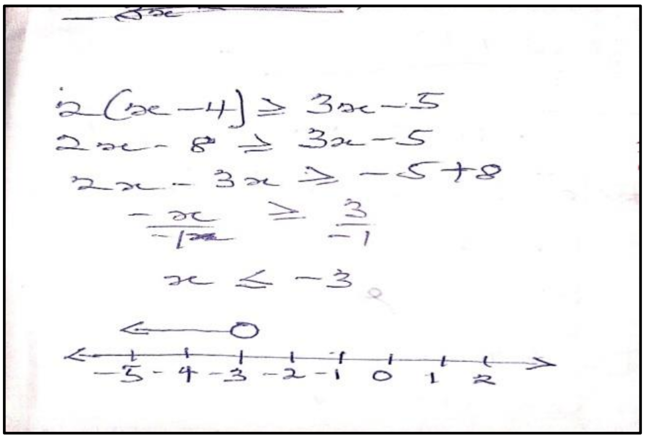

Figure 7. Representation of Inequalities on the Number Line

Upon reviewing Figure 7, it was identified that 47% of the student-teachers held misconceptions regarding the graphical representation of inequalities on a number line. For instance, upon deriving an inequality solution such as x>1, some student-teachers incorrectly shaded the opposite side or direction. This suggests limited geometric understanding or difficulty interpreting inequality symbols. Some student-teachers exhibited a lack of comprehension in the semantic value of mathematical terms like "greater than" or "greater than or equal to."

Case 8: Misidentification of Common Denominator

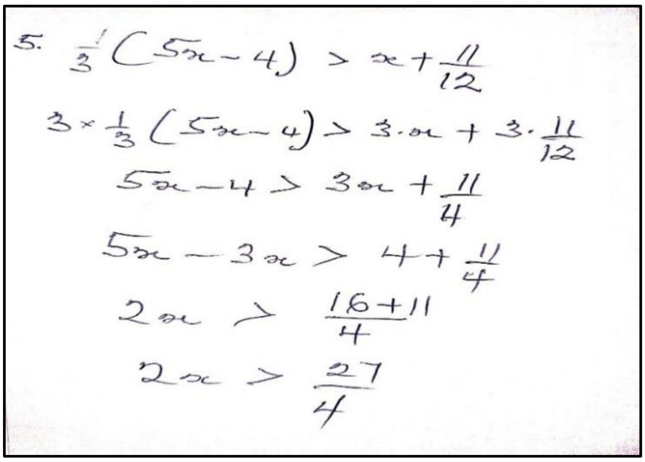

Figure 8. Misidentification of Common Denominator

In Figure 8, two distinct errors were detected, both revolving around the incorrect identification of a common denominator for a pair of numbers or variables. When seeking the common denominator of two numbers, some pre-service teachers erroneously selected the smaller number, rendering the rest of the process incorrect. Conversely, when faced with algebraic fractions, student-teachers incorrectly identified the sum of the denominators as the common denominator, rather than their product.

Research Question 2: Why do student-teachers commit errors and misconceptions in linear inequalities?

In this research question, seven simple questions were posed to student-teachers to illicit more information about the reasons for committing the errors. Instead of written narratives, the researchers transcribed and coded verbal narratives. These responses enabled the researchers to identify to help address the errors and misconceptions in subsequent lessons.

Question 1 : *Why do you encounter errors when using the number line to solve problems in linear inequalities?*
Respondent 1 : *My mathematics teacher uses the number line method as the teaching preference for the addition and subtraction of linear inequalities. So, i do not understand the inequality signs on the number line.*

Question 2 : *Why do you forget to reverse the inequality sign in linear inequities?*
Respondent 10 : *When it comes to the multiplication of linear inequalities, the teacher would ask us to memorize the multiplication table and the rules of multiplication and division. So, anytime I want to reverse I just apply the rules straightforward.*

Question 3 : *Why do you have problems working with linear inequalities?*
Respondent 3 : *Because we have many topics to complete before the semester is over when our teachers ask us to memorise something, we just memorise them without seeking further explanation. The teacher will later give us lots of exercises and we use what we have memorised to answer the questions.*

Question 4 : *Why don't you consult your tutor whenever you find challenges in linear inequalities?*
Respondent 4 : *Since we are many in the classroom, the teachers find it difficult to explain one thing over and over, especially to those who do not understand.*

Question 5 : *Why don't you understand linear inequalities when you are taught?*
Respondent 5 : *Teachers rush us through the linear inequalities because they said it is an easy topic even though not all students can understand something within a few hours. Weak students need more time to understand and at the same time, the teachers cannot wait for them.*

Question 6 : *Why do you have inadequate knowledge with solving linear inequalities?*
Respondent 6 : *Some teachers themselves find it difficult to explain the concept to us using real-life examples. So, they only give us formulas to memorise so that we can answer questions for them. Since we do not understand these things, we also find it difficult to explain to our friends why the things are how they are.*

Question 7 : *Why don't refer to text book when solving problems in linear inequalities?*
Respondent 7 : *The textbooks that we use do not provide much insight on the linear inequality topics. Hence, I just memorise the formulas and use them to answer the questions.*

Discussion of Findings

Definitions of errors and misconceptions in linear inequalities

A frequent definition of the term misconception is an erroneous perception or belief. The belief of an incorrect fact does not constitute a misconception. Incorrect facts can be erased easily by communicating pertinent information. However, a misconception includes a deep framework of conceptual thinking that has been perpetuated through many years. Also, researchers have presented various definitions of misconceptions (Britannica, 2021). To demonstrate intellectual respect for the learner who holds those views, some researchers prefer to refer to misconceptions as alternative frameworks or alternative conceptions. For instance, on Table 1, linear inequalities are alternative conceptions of linear equations. So, whenever the student-teacher uses the linear equations they erroneously think the end results would be the same. The error in definitions is a major problem to the understanding of linear inequalities.

Differentiating Linear Inequalities from Linear Equations

Although the process for solving inequalities appears to be identical to that for solving equations, there are a few distinctions that students frequently ignore. Teachers can assist students in recognizing these discrepancies and using multiple solution methods to solve inequalities. Many students disregard the importance of following the order of operations principles and solving the expression from left to right. Many students are unaware that parentheses can signify multiplication and grouping i.e. (20-7) = -13. When solving inequalities, students frequently use equation-solving

procedures. This misunderstanding is reasonable because equations and inequalities are similar. However, the differences are observed in the symbols (i.e. $2x-1< 0$ and $2x-1= 0$ are different), the reversals of signs (e.g. $-2x < 6$ or $x > -3$), substitute inequality after working an equation (e.g. $-65x^3 > 0$ is the same way as solving equation: $-65x^3 = 0$). Then, they arrive at the conclusion that $x^3 = 0$, and then $x= 0$. When they put the sign back, some students may most likely obtain $x > 0$ to solve the inequality and NOT $x < 0$ (Karthik, 2023).

Causes of errors and misconceptions errors in linear inequalities

Errors can occur for a diversity of reasons. An error can be triggered by carelessness, a misinterpretation of a symbol or text, or a lack of understanding and practice regarding linear equalities. It could be due to a lack of awareness or an inability to double-check the answers offered, or it could be due to a misconception. A primary premise in distinguishing between an error and a misconception is that errors are immediately detectable in learners' work, such as written text or speech, whereas misconceptions are frequently disguised from casual observation. Research findings (Gravemeijer et al., 2017; Institute of Education, 2019; Jupri et al., 2022) allude that learners make errors due to existing conceptual gaps or misconceptions embedded in their conceptual schemes. If errors and misconceptions were to be put on a continuum, one would have non-systematic errors on one end and the more serious systematic errors deeply rooted in misconceptions on the opposite end.

Student-teachers' conceptions of linear inequalities

The narratives showed on Figures 1-9 that in general, tutors who teach the student-teachers devote little time to complete the topic of linear inequalities. Within that little time, most tutors prefer to use only the number line approach as a teaching strategy. All the respondents agreed that their tutors used direct instruction and classroom lecture style in explaining the concept of linear inequalities (Arnawa et al., 2019). Additionally, the tutors just provided their student-teachers with the rules and procedures to solve the linear inequality problems. This is because they needed to finish all the topics in the curriculum within a certain time frame. Thus, it is impossible to merely focus on one topic and neglect the other topics. When this happens, student-teachers are bound to lack the understanding of the concept since they have not been thought with any examples to make the teaching real to them. For teachers, this is the reason to explain their inability to focus more on only one topic and to not finish the other topics. Therefore, they prefer to use any method of teaching that can reduce the time (Fumador & Agyei, 2018).

Furthermore, student-teachers fail to grasp the concept of linear inequalities and ended up committing errors and misconceptions are that there are too many student-teachers in one classroom with different learning abilities. Hence, a classroom may have student-teachers with strong cognitive abilities and students with weak cognitive abilities. Therefore, tutors have to spend more time to cater for the differing abilities of the student-teachers. This becomes difficult at a point since teachers have to move from one topic to the other because they are working within a time frame. This also justifies why the teachers rush the students through the topics without proper explanation of the concepts. The findings of Khalid and Embong (2020) suggest that teachers' teaching methods, teachers rushing to complete the extensive syllabus, and consequently, students resorted to memorizing rules because of surface understanding were the major sources of errors and misconceptions in understanding mathematical concepts.

CONCLUSIONS

Based on the findings of this study, several key conclusions were drawn. Firstly, it was clear that student-teachers struggle with accurately applying the fundamental rules when solving problems in linear inequalities. A noticeable lack of procedural fluency and skills has resulted in these student-teachers arriving at incorrect solutions. Secondly, student-teachers face considerable difficulty in manipulating symbols, particularly when they have to multiply or divide by negative coefficients during linear inequality solutions. This challenge extends to their ability to formulate linear inequality problems from real-life word problems, leading to solutions that often don't reflect

practical scenarios. The inherent complexity of linear inequalities seems to hinder their ability to make connections to real-life situations. Thirdly, a common source of confusion among student-teachers stems from the differing solution approaches required for linear equations and linear inequalities. This conceptual hurdle often leaves them perplexed and unsure. Lastly, the prevalence of errors and misconceptions in solving linear inequality problems is exacerbated by poor and inappropriate teaching methods, limited resources, reliance on memorization, and unstructured textbooks.

Given these conclusions, it is recommended that educators, administrators, and other stakeholders work collaboratively to facilitate effective instruction in linear inequalities. Timely intervention to address the challenges faced by student-teachers is essential. Encouraging student-teachers to engage in the formulation of linear problems both in the classroom and at home can foster better understanding and problem-solving skills. Teacher educators need to reimagine modern and engaging teaching methodologies that promote an active and cooperative learning environment. This approach could enhance student-teachers' conceptual understanding through peer interaction. Further, they should make use of instructional resources that strengthen students' procedural knowledge in linear inequalities. Involving them in tasks that employ multiple representations of inequality symbols (<, >, ≤, ≥) could deepen their understanding and ability to manipulate linear inequality tasks.

AUTHOR CONTRIBUTION STATEMENT

AMH : Designing, conceptualizing ideas, and analyzing data.
KU : Assessment instruments, manuscript drafting, correcting, and final approval.
RD : Editing, reviewing, proofreading, and providing technical support.

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